

What is claimed is:

1. A magneto-resistance effect element comprising:
  - a lower conductive layer;
  - a free layer provided on the lower conductive layer and  
5 having an orientation of magnetization varied by a magnetic field applied thereto;
  - a non-magnetic layer provided on top of the free layer;
  - a fixed layer provided on the non-magnetic layer and  
having a pinned orientation of magnetization; and  
10 a vertical bias layer, provided on said lower conductive layer, for applying a magnetic field to said free layer, and said free layer is greater in length in the direction of a magnetic field applied thereto by said vertical bias layer than said fixed layer, and a sense current for detecting a change in electrical  
15 resistance of said non-magnetic layer flows substantially in perpendicular relation to said non-magnetic layer.
2. The magneto-resistance effect element according to claim 1, wherein said lower conductive layer has a recessed portion on an upper surface thereof, and said vertical bias layer  
20 is provided so as to allow at least part thereof to be buried in said recessed portion.
3. The magneto-resistance effect element according to claim 1, wherein at least part of said free layer is in direct contact with said vertical bias layer.
- 25 4. The magneto-resistance effect element according to claim 1, further comprising an underlying layer for free layer provided under said free layer, and said Underlying layer for free layer in contact with said free layer and said vertical bias

layer.

5. The magneto-resistance effect element according to claim 1, further comprising a vertical bias layer protective layer provided on said vertical bias layer, and said vertical  
5 bias layer protective layer is in contact with said vertical bias layer, and said vertical bias layer protective is in contact with layer at least one of said free layer and said Underlying layer for free layer.

6. A magneto-resistance effect element comprising:  
10 a lower conductive layer;  
a magnetic layer provided on the lower conductive layer;  
a free layer provided on the magnetic layer and having an orientation of magnetization varied by a magnetic field coupled magnetically to the magnetic layer and applied thereto;  
15 a non-magnetic layer provided on the free layer;  
a fixed layer provided on the non-magnetic layer and having a pinned orientation of magnetization; and  
a vertical bias layer, provided on said lower conductive layer, for applying a magnetic field to said free layer, and said  
20 magnetic layer is greater in length in the direction of a magnetic field applied thereto by said vertical bias layer than said free layer, and a sense current for detecting a change in electrical resistance of said non-magnetic body flows substantially in perpendicular relation to said non-magnetic  
25 layer.

7. The magneto-resistance effect element according to claim 6, wherein said magnetic layer is magnetically coupled to said free layer by anti-ferromagnetic coupling or ferromagnetic

coupling.

8. The magneto-resistance effect element according to claim 6, wherein said lower conductive layer has a recessed portion on an upper surface thereof, and said vertical bias layer  
5 is provided so as to allow at least part thereof to be buried in said recessed portion.

9. The magneto-resistance effect element according to claim 6, wherein at least part of said free layer is in direct contact with said vertical bias layer.

10        10. A magneto-resistance effect element comprising:  
a lower conductive layer;  
a fixed layer provided on the lower conductive layer and having a pinned orientation of magnetization;  
a non-magnetic layer provided on the fixed layer;  
15        a free layer provided on the non-magnetic layer and having an orientation of magnetization varied by a magnetic field applied thereto;  
a magnetic layer provided on the free layer and magnetically coupled to the free layer; and  
20        a vertical bias layer for applying a magnetic field to said magnetic layer, and a sense current for detecting a change in electrical resistance of said non-magnetic layer flows substantially in perpendicular relation to said non-magnetic layer.

25        11. The magneto-resistance effect element according to claim 10, wherein said magnetic layer is equal to or greater than said free layer in length in the direction of the magnetic field applied by said vertical bias layer.

12. The magneto-resistance effect element according to claim 10, further comprising a fixing layer, disposed between said lower conductive layer and said fixed layer, for pinning the orientation of magnetization of said fixed layer.

5        13. The magneto-resistance effect element according to claim 10, wherein said magnetic layer is magnetically coupled to said free layer by anti-ferromagnetic coupling or ferromagnetic coupling.

10       14. The magneto-resistance effect element according to claim 10, wherein at least part of said magnetic layer is in direct contact with said vertical bias layer.

15       15. A magneto-resistance effect element comprising:  
         a lower conductive layer;  
         a fixed layer provided on the lower conductive layer and  
         having a pinned orientation of magnetization;  
         a first non-magnetic layer provided on the fixed layer;  
         a free layer provided on the first non-magnetic layer and  
         having an orientation of magnetization varied by a magnetic field  
         applied thereto;  
20       a first magnetic layer provided on the free layer and  
         magnetically coupled to the free layer;  
         a second magnetic layer provided on the first magnetic  
         layer and magnetically coupled to the first magnetic layer; and  
         a vertical bias layer for applying a magnetic field to  
25       said first and second magnetic layers, and a sense current for  
         detecting a change in electrical resistance of said first non-  
         magnetic layer flows substantially in perpendicular relation to  
         said first non-magnetic layer.

16. The magneto-resistance effect element according to claim 15, wherein said first magnetic layer is equal to or greater than said free layer in length in the direction of the magnetic field applied by said vertical bias layer.

5        17. The magneto-resistance effect element according to claim 15, wherein said second magnetic layer is equal to or greater than said free layer in length in the direction of the magnetic field applied by said vertical bias layer.

10       18. The magneto-resistance effect element according to claim 15, further comprising a fixing layer, disposed between said lower conductive layer and said fixed layer, for pinning the orientation of magnetization of said fixed layer.

15       19. The magneto-resistance effect element according to claim 15, further comprising a second non-magnetic layer between said free layer and said first magnetic layer.

20       20. The magneto-resistance effect element according to claim 15, further comprising a third non-magnetic layer between said first magnetic layer and said second magnetic layer.

20       21. The magneto-resistance effect element according to claim 15, wherein said free layer is magnetically coupled to said first magnetic layer by anti-ferromagnetic coupling or ferromagnetic coupling.

25       22. The magneto-resistance effect element according to claim 15, wherein said first magnetic layer is magnetically coupled to said second magnetic layer by anti-ferromagnetic coupling or ferromagnetic coupling.

23. The magneto-resistance effect element according to claim 15, wherein the product of saturation magnetization and

film thickness of said first magnetic layer is substantially equal to the product of saturation magnetization and film thickness of said second magnetic layer.

24. The magneto-resistance effect element according to  
5 claim 20, wherein a three-layered film made up of said first magnetic layer, said third non-magnetic layer, and said second magnetic layer is a layered antiferromagnetic body.

25. The magneto-resistance effect element according to  
claim 15, wherein at least part of said first magnetic layer is  
10 in direct contact with said vertical bias layer.

26. The magneto-resistance effect element according to  
claim 15, wherein at least part of said second magnetic layer is  
in direct contact with said vertical bias layer.

27. A magneto-resistance effect element comprising:  
15 a lower conductive layer;  
a fixed layer provided on the lower conductive layer and  
having a pinned orientation of magnetization;  
a non-magnetic layer provided on the fixed layer;  
a free layer provided on the non-magnetic layer and having  
20 an orientation of magnetization varied by a magnetic field  
applied thereto;

a magnetic layer provided on the free layer; and  
a vertical bias layer, provided on the magnetic layer, for  
applying a magnetic field to said magnetic layer, and a sense  
25 current for detecting a change in electrical resistance of said  
non-magnetic layer flows substantially in perpendicular relation  
to said non-magnetic layer.

28. The magneto-resistance effect element according to

claim 27, further comprising a second magnetic layer between said magnetic layer and said vertical bias layer.

29. A magneto-resistance effect element comprising:

a lower conductive layer;

5 a first fixed layer provided on the lower conductive layer and having a pinned orientation of magnetization;

a first non-magnetic layer provided on the first fixed layer;

a first free layer provided on the first non-magnetic layer and having an orientation of magnetization varied by a magnetic field applied thereto;

a magnetic layer provided on the first free layer and magnetically coupled to the first free layer;

a second free layer provided on the magnetic layer and magnetically coupled to the magnetic layer;

a second non-magnetic layer provided on the second free layer;

a second fixed layer provided on the second non-magnetic layer and having a pinned orientation of magnetization; and

20 a vertical bias layer for applying a magnetic field to said magnetic layer, and a sense current for detecting a change in electrical resistance of said first and second non-magnetic layers flows substantially in perpendicular relation to said first and second non-magnetic layers.

25 30. The magneto-resistance effect element according to claim 29, wherein said magnetic layer is equal to or greater than said first and second free layers in length in the direction of the magnetic field applied by said vertical bias layer.

31. The magneto-resistance effect element according to claim 29, further comprising a first fixing layer, disposed below said first fixed layer, for pinning the orientation of magnetization of said first fixed layer.

5        32. The magneto-resistance effect element according to claim 29, further comprising a second fixing layer, disposed above said second fixed layer, for pinning the orientation of magnetization of said second fixed layer.

33. The magneto-resistance effect element according to  
10 claim 29, wherein said first free layer is magnetically coupled to said magnetic layer by anti-ferromagnetic coupling or ferromagnetic coupling.

34. The magneto-resistance effect element according to claim 29, wherein said magnetic layer is magnetically coupled to  
15 said second free layer by anti-ferromagnetic coupling or ferromagnetic coupling.

35. The magneto-resistance effect element according to claim 29, wherein at least part of said magnetic layer is in direct contact with said vertical bias layer.

20        36. A magneto-resistance effect element comprising:  
a lower conductive layer;  
a first magnetic layer provided on the lower electrically conductive;

a second magnetic layer provided on the first magnetic  
25 layer and magnetically coupled to the first magnetic layer;

a free layer provided on the second magnetic layer, magnetically coupled to the second magnetic layer, and having an orientation of magnetization varied by a magnetic field applied



thereto;

a first non-magnetic layer provided on the free layer;

a fixed layer provided on the first non-magnetic layer and having a pinned orientation of magnetization; and

5 a vertical bias layer for applying a magnetic field to said first magnetic layer, and a sense current for detecting a change in electrical resistance of said first non-magnetic layer flows substantially in perpendicular relation to said first non-magnetic layer.

10 37. The magneto-resistance effect element according to claim 36, wherein said first magnetic layer is equal to or greater than said free layer in length in the direction of the magnetic field applied by said vertical bias layer.

15 38. The magneto-resistance effect element according to claim 36, wherein said second magnetic layer is equal to or greater than said free layer in length in the direction of the magnetic field applied by said vertical bias layer.

20 39. The magneto-resistance effect element according to claim 36, further comprising a fixing layer, disposed on said fixed layer, for pinning the orientation of magnetization of said fixed layer.

40. The magneto-resistance effect element according to claim 36, further comprising a second non-magnetic layer between said first magnetic layer and said second magnetic layer.

25 41. The magneto-resistance effect element according to claim 36, further comprising a third non-magnetic layer between said second magnetic layer and said free layer.

42. The magneto-resistance effect element according to

claim 36, wherein said free layer is magnetically coupled to said second magnetic layer by anti-ferromagnetic coupling or ferromagnetic coupling.

43. The magneto-resistance effect element according to  
5 claim 36, wherein said first magnetic layer is magnetically coupled to said second magnetic layer by anti-ferromagnetic coupling or ferromagnetic coupling.

44. The magneto-resistance effect element according to  
claim 36, wherein the product of saturation magnetization and  
10 film thickness of said first magnetic layer is substantially equal to the product of saturation magnetization and film thickness of said second magnetic layer.

45. The magneto-resistance effect element according to  
claim 36, wherein a three-layered film made up of said first  
15 magnetic layer, said second non-magnetic layer, and said second magnetic layer is a layered antiferromagnetic body.

46. The magneto-resistance effect element according to  
claim 36, wherein at least part of said first magnetic layer is  
in direct contact with said vertical bias layer.

20 47. The magneto-resistance effect element according to  
claim 36, wherein at least part of said second magnetic layer is  
in direct contact with said vertical bias layer.

48. A magneto-resistance effect element comprising:  
a lower conductive layer;  
25 a vertical bias layer provided on the lower conductive  
layer;  
a first magnetic layer provided on the vertical bias  
layer;

a second magnetic layer provided on the first magnetic layer and magnetically coupled to the first magnetic layer;

a free layer provided on the second magnetic layer, magnetically coupled to the second magnetic layer, and having an orientation of magnetization varied by a magnetic field applied thereto;

a first non-magnetic layer provided on the free layer; and

a fixed layer provided on the first non-magnetic layer and having a pinned orientation of magnetization, and a sense current for detecting a change in electrical resistance of said first non-magnetic layer flows substantially in perpendicular relation to said first non-magnetic layer.

49. The magneto-resistance effect element according to claim 48, wherein said first magnetic layer is equal to or greater than said free layer in length in the direction of the magnetic field applied by said vertical bias layer.

50. The magneto-resistance effect element according to claim 48, wherein said second magnetic layer is equal to or greater than said free layer in length in the direction of the magnetic field applied by said vertical bias layer.

51. The magneto-resistance effect element according to claim 48, further comprising a second non-magnetic layer between said first magnetic layer and said second magnetic layer.

52. The magneto-resistance effect element according to claim 48, further comprising a third non-magnetic layer between said second magnetic layer and said free layer.

53. The magneto-resistance effect element according to claim 48, wherein said free layer is magnetically coupled to said

second magnetic layer by anti-ferromagnetic coupling or ferromagnetic coupling.

54. The magneto-resistance effect element according to claim 48, wherein said first magnetic layer is magnetically  
5 coupled to said second magnetic layer by anti-ferromagnetic coupling or ferromagnetic coupling.

55. The magneto-resistance effect element according to claim 48, wherein the product of saturation magnetization and film thickness of said first magnetic layer is substantially  
10 equal to the product of saturation magnetization and film thickness of said second magnetic layer.

56. The magneto-resistance effect element according to claim 48, wherein a three-layered film made up of said first magnetic layer, said second non-magnetic layer, and said second  
15 magnetic layer is a layered antiferromagnetic body.

57. The magneto-resistance effect element according to claim 48, wherein at least part of said first magnetic layer is in direct contact with said vertical bias layer.

58. The magneto-resistance effect element according to  
20 claim 48, wherein at least part of said second magnetic layer is in direct contact with said vertical bias layer.

59. A magneto-resistance effect head comprising:  
said magneto-resistance effect element according to claim  
1;  
25 a lower shield layer serving as a substrate for said magneto-resistance effect element;

an upper conductive layer, provided on said magneto-resistance effect element, for inputting a sense current for

detecting a change in electrical resistance of said magneto-resistance effect element into said magneto-resistance effect element; and

an upper shield layer provided on the upper conductive  
5 layer.

60. The magneto-resistance effect head according to claim 59, wherein the lower conductive layer of said magneto-resistance effect element is integrated with said lower shield layer.

61. The magneto-resistance effect head according to claim  
10 59, wherein said upper conductive layer is integrated with said upper shield layer.

62. A magneto-resistance transducer system comprising:  
said magneto-resistance effect head according to claim 59;  
an electric current generator circuit for supplying a  
15 sense current to said magneto-resistance effect head; and

a data read circuit for detecting a change in electrical resistance of said magneto-resistance effect head to determine a magnetic field applied to said magneto-resistance effect head.

63. A magnetic storage system comprising:  
20 said magneto-resistance transducer system according to claim 62;

a magnetic storage medium having a plurality of tracks for allowing said magneto-resistance transducer system to write and read data thereon;

25 a first actuator for moving said magneto-resistance transducer system to where a selected track is located in said magnetic storage medium; and

a second actuator for rotatably driving said track.